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Original Article

Delayed primary closure versus primary closure for wound management in perforated appendicitis: A prospective randomized controlled trial

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Abstract

Background: It is still a matter of debate whether delayed primary closure (DPC) of contaminated abdominal incisions reduces surgical site infections compared with a primary closure (PC). The aim of this study was to determine the optimal method of wound closure for patients with perforated appendicitis.
Methods: A total of 70 patients with perforated appendicitis were included. They were randomized to have their surgical incisions (skin and subcutaneous tissue) either PC or left open with Betadine-soaked gauze packing for DPC on the fifth postoperative day or later if the wound conditions were inappropriate for closure. A wound was considered infected if pus discharged from the incision site. The main outcome measures were the incidence of wound infection and the length of hospital stay (LOS).
Results: In the entire series, wound infection developed after incision closure in 21.4% of the patients. The PC group had a higher incidence of wound infection (38.9% vs. 2.9%, $p < 0.001$) and longer LOS (8.4 days vs. 6.3 days, $p = 0.038$).
Conclusion: Delayed primary closure is the optimal management strategy for perforated appendicitis wounds. It significantly reduces the wound infection rate and length of stay.

Keywords: delayed primary closure; perforated appendicitis; primary closure

1. Introduction

Appendectomy is still the most common emergency surgical procedure. Despite the use of antibiotics that target both aerobic and anaerobic organisms, postoperative wound infection remains the most frequent complication in patients with perforated appendicitis, with resulting infection rates anywhere from 25%−50% in most reported series.[1] Of the many risk factors influencing postoperative wound infection, the method of skin closure has been implicated as an important factor. Delayed primary closure (DPC) and primary closure (PC) are two commonly used methods, but there is no consensus as to the optimal method. Cruse and Foord[2] found in a retrospective survey a wound infection rate of 40% among 2,093 dirty wounds, but they did not specify how skin closure was performed. Three prospective randomized studies[3−5] for management of perforated appendicitis wounds showed no advantage to DPC in terms of decreased wound infection compared with PC, whereas another retrospective studies[6,7] showed DPC could more significantly reduce wound infection rate than PC. We conducted a prospective study on patients with perforated appendicitis to determine that whether the strategy of DPC could result in a decreased rate of wound infection.

2. Methods

2.1. Study population and surveillance of wound infection

The study was approved by the Institutional Review Board of Mackay Memorial Hospital. A total of 70 consecutive patients with perforated appendicitis were included during the

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2-year period from January 2008 to December 2009. Perforated appendicitis was defined as gross perforation identified by surgeons at the time of operation; microscopic perforation identified by the pathologist was not included. All patients received perioperative intravenous antibiotics with anaerobic coverage until normalization of temperature, white blood cell (WBC) count and gastrointestinal function. They underwent conventional appendectomy through a McBurney's point muscle-splitting incision with the stump of the appendix buried. Turbid ascites were cultured, and peritoneal lavage was performed with warm saline until clear effluent was restored. Soft rubber Penrose drains were placed in the pelvis and paracolic gutter through a separate incision in the abdominal wall. The peritoneum, muscle, and fascia were closed in layers. Based on the date of operation, the patients were allocated to either one of the following two strategies for wound management: PC for patients whose operations occurred on odd dates, and DPC for those operations occurred on even dates. For PC, wounds were closed with monofilament nylon interrupted sutures. For DPC, skin and subcutaneous tissue were left open and packed with diluted Betadine (0.5% povidone iodine)-soaked gauze that was changed daily to prevent excessive collection of exudate. If the wound appeared clean on postoperative Day 5, it was repaired under local anesthesia in operating room. Otherwise, wet packing was continued, then DPC was performed on a later date, when the wound became clean. Wound infection was defined as the presence of gross purulent discharge at the incision site, with or without a positive bacterial culture. Infected wounds in both groups were opened and packed, and bacterial culture of the pus was made. Possibly infected wounds were observed closely and opened if purulent discharge, increasing erythema, induration, or warmth developed.

2.2. Demographics

The following data were collected: age, sex, duration of symptoms (time from the onset of symptoms to operation), WBC on admission, hospital length of stay (LOS) and the presence of wound infection.

We also tabulated underlying medical conditions that could contribute to infectious complications: diabetes mellitus, obesity (body mass index > 30 kg/m^2), malnutrition (clinical observation of muscle wasting or albumin level < 2.5 g/dl), steroid use, and cardiovascular disease.[8] Other immunocompromising diseases such as malignancy, uremia or liver cirrhosis were not present in our patients.

2.3. Statistical analysis

The sample size was estimated with using an alpha error of 0.05 and a beta error of 0.20, and provided 80% statistical power for the detection of > 20% difference in wound infection rates between the two groups. The chi-square and Fisher exact tests were used to determine whether any association between the presence of wound infection and the type of skin closure existed. Mean comparisons were performed by the two-sample Student *t*-test. A *p* value of less than 0.05 was considered to be statistically significant. Data are presented as mean ± standard deviation or as a percentage.

3. Results

Of the 70 patients included in our study, 41 were males and 29 were females. Mean age was 37.8 years (range, 3–83 years). No patient was withdrawn from the study, and there was no perioperative mortality or major complication such as organ failure, appendiceal stump leakage or intra-abdominal abscess.

All 70 patients received the allocated interventions, 34 in the DPC group and 36 in the PC group. Both groups of patients were similar in terms of sex, age, and underlying medical risk factors. The proportion of patients with one or more risk factors was similar (DPC 20.6% vs. PC 16.7%, $p = 0.385$). There was no significant difference in the duration of symptoms and WBC count between both groups ($p = 0.273$ and 0.182, respectively). These results are shown in Table 1.

In the entire series, 15 patients (21.4%) developed wound infection after DPC or PC. The most common organisms cultured from the wounds were *Escherichia coli* (53%), *Bacteroides fragilis* (27%), and various Streptococci (20%). These organisms were compatible with those cultured from ascites during operation (Table 2). There was one wound infection in the DPC group, where purulent discharge from the wound was noted 3 days after DPC. The wound was reopened and pus culture yielded *E coli*, which was identical to the bacteria cultured from ascites during operation. All other wounds were observed for at least two weeks after DPC, and none had to be reopened. Thus, the wound infection rate for DPC was 1/34 (2.9%). These results are shown in Table 3.

In the PC group, similarly followed-up for at least 2 weeks after surgery, there were 14 wound infections (38.9%). There was a significant association between wound infection and type of skin closure (DPC 2.9% vs. PC 38.9%, $p < 0.001$).

There were two wound infection associated readmissions in the PC group. The LOS for each readmission was added to the

Table 1
Patient demographics and clinical manifestation.

	DPC ($n = 34$)	PC ($n = 36$)	p value
Male/female	20/14	21/15	0.910
Mean age (y)	38.2 ± 15.9	37.5 ± 18.3	0.682
Risk factors			
Patients with ≥ one risk factor	7 (20.6%)	6 (16.7%)	0.385
Diabetes mellitus	2	2	
Malnutrition	1	2	
Steroid use	1	0	
Cardiovascular disease	3	2	
Obesity (body mass index > 30)	4	3	
Duration of symptoms (d)	2.5 ± 0.3	2.2 ± 0.2	0.273
WBC (×1000/ul)	16.5 ± 1.0	14.8 ± 0.8	0.182

Data are presented as mean ± standard deviation or n (%).
DPC = delayed primary closure; PC = primary closure; WBC = white blood cell.

Table 2
Bacteria cultured from ascites and wound pus.

	Ascites ($n = 70$)		Wound pus ($n = 15$)	
	DPC ($n = 34$)	PC ($n = 36$)	DPC ($n = 1$)	PC ($n = 14$)
No growth	3	3	0	1
Escherichia coli	21	26	1	7
Bacteroides fragilis	20	18	0	4
Streptococcal species	10	7	0	3
Pseudomonas aeruginosa	2	3	0	2
Clostridial species	5	2	0	0

DPC = delayed primary closure; PC = primary closure.

LOS of the patient's previous admission. There was no readmission in the DPC group. Analyzing the LOS, there was significant difference between both groups (DPC 6.3 ± 0.7 days vs. PC 8.4 ± 0.9 days, $p = 0.038$).

4. Discussion

Open-wound management of contaminated wounds is a practical measure that has been used for centuries.[9] Theodor Billroth was a proponent of open wound management in the 1860s.[10] The use of DPC was popularized by military surgeons, where tremendous experience in wound management was gained during two world wars and the Korean war. At that time DPC was performed only after the appearance of a healthy wound, usually at 3-7 days after surgery.[11]

The incidence of postoperative wound infection after appendectomy substantially increases with the severity of the appendicitis treated, and most infections occur after emergency appendectomy for perforated appendicitis.[12,13] Bacterial contamination of the wound during surgery is the major factor responsible for the development of a subsequent wound infection. The offending organisms are predominantly bacteria from the colonic flora.[14] Recently, several groups have published updated guidelines for the choice of appropriate prophylactic antibiotics in abdominal surgery.[15,16] Some authors consider that perioperative antibiotic administration allows for PC of all appendectomy wounds, despite data suggesting that contaminated wounds have a higher rate of wound infection.[17] This practice has been aggressively pursued by surgeons on the basis of its association with a "low" incidence of infectious complications, the elimination of painful and time-consuming dressing changes and reduction in cost.[18–20] PC of acute appendicitis with perforation has also found its way into the management algorithm, without adequate assessment of adverse outcomes.

Grosfeld and Solit[21] in 1968 reviewed perforated appendicitis wounds and found a wound infection rate of 2.3% for DPC compared to 14.6% with PC. More recently, Lemieur and coworkers[6] found a wound infection rate in perforated appendicitis of 24% when the incision was closed primarily, and Yellin and colleauges[22] found a wound infection rate of 4% after DPC of all their advanced appendicitis wounds. Chiang and others[7] in 2006 found a wound infection rate of 4.2% in DPC group of patients with perforated appendicitis compared with 43.9% in PC group.

Table 4[3–5] summarizes the results of three previous prospective randomized trials comparing DPC with PC in the literature. Tsang and colleagues[3] studied 63 children with gangrenous or perforated appendicitis and found no difference in the rate of wound infection between the two groups. Pettigrew[4] and Anderson and others[5] both studied more than 80 patients with gangrenous or perforated appendicitis and also found no significant difference. These authors used normal saline as the gauze-soaking agent in the DPC group, whereas our study used Betadine solution as the soaking agent. The different methods for wound packing might contribute to the difference in the wound infection rate in the DPC groups between the previous studies and our study. Furthermore, these previous studies may be somewhat dated, highlighting the need to address this issue with a more recent trial.

The method of DPC has the advantage of reducing the numbers of colonic bacteria, particularly anaerobes, contaminating to the wound.[4] However, the disadvantage of allowing exogenous bacteria such as Staphylococci to contaminate the wounds in the ward before closure has been recognized.[11] In our study, cross infection was not a problem in patients treated with DPC, and the organism responsible for wound infection was identical to that cultured from the intraoperative peritoneal fluid.

Laparoscopic appendectomy in expert hands is now quite safe and effective, and it is a good alternative for patients with acute appendicitis. Most cases of acute appendicitis, even perforated appendicitis, can be treated laparoscopically. This method can reduce LOS and minimize complications to a greater extent than conventional open surgery; however, it is more complex and is not widely available. Like many surgeons in Taiwan, we are still doing open appendectomies for all patients with acute appendicitis in our hospital. Minimal access surgery requires a different skill set, and supplemental and technological knowledge. With a clear diagnosis of complicated appendicitis, the skill and experience of the surgeon should be considered when choosing an operating method. Surgeons should perform the procedure with which they are more comfortable.

Table 3
Wound infection rate and length of stay.

	DPC ($n = 34$)	PC ($n = 36$)	p value
WI	1 (2.9%)	14 (38.9%)	< 0.001
LOS (d)	6.3 ± 0.7	8.4 ± 0.9	0.038

DPC = delayed primary closure; LOS = length of stay; PC = primary closure; WI = wound infection.

Table 4
Results of prospective randomized studies.

	DPC		PC		Comments
	n	WI	n	WI	
Anderson (1972)[5]	58	15 (26%)	58	20 (34%)	NS
Pettigrew (1981)[4]	42	23 (54%)	41	15 (37%)	NS
Tsang (1992)[3]	25	6 (24%)	38	8 (21%)	NS
Present series	34	1 (2.9%)	36	16 (38.9%)	$p < 0.001$

DPC = delayed primary closure; NS = not significant; PC = primary closure; WI = wound infection.

Our study found that in patients undergoing open appendectomy for perforated appendicitis, DPC was the optimal method for wound management because of a lower incidence of wound infection and a shorter LOS when compared with PC. In conclusion, DPC is the strategy of choice for wound management in patients with perforated appendicitis.

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